ADDENDA

ANSI/ASHRAE Addendum e to
ANSI/ASHRAE Standard 160-2009

Criteria for Moisture-Control Design Analysis in Buildings

Approved by ASHRAE on November 30, 2016, and and by the American National Standards Institute on November 30, 2016.

This addendum was approved by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE website (www.ashrae.org) or in paper form from the Senior Manager of Standards.

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 ISSN 1041-2336

Approved American National Standard
www.ansi.org

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FOREWORD

This addendum revises Sections 6.1 and 7.5 as indicated below. Since the publication of Standard 160-2009, it has become apparent that the performance evaluation criteria for mold growth are too stringent. Section 6.1 currently prescribes a simplified criterion that is easy to calculate but difficult to meet: a flat 80% 30-day running average surface relative humidity criterion, bounded by temperatures between 5°C (41°F) and 40°C (104°F). A number of researchers and practitioners have reported to the committee that assemblies that are known to have satisfactory performance in reality are failing the criterion in simulation. Furthermore, the scientific literature indicates that mold growth requires a much more complex description. Mathematical models have been developed that predict mold growth risk as a function of time, surface temperature, and surface relative humidity. Such models can readily use as inputs the hourly outputs of a hygrothermal simulation. The mold growth model selected for implementation in Section 6.1 of Standard 160 by this addendum is empirical and has been validated with experimental data for different materials with varying sensitivities to mold growth. This addendum will bring the standard more in line with the current state of knowledge about mold growth while providing a less stringent criterion. Changes to Section 7.5 bring the reporting requirements in line with the changes to Section 6.1.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum e to Standard 160-2009

Revise Section 6.1 as follows.

6.1 Conditions Necessary to Minimize Mold Growth. In order to minimize problems associated with mold growth on the surfaces of components of building envelope assemblies, ~~the following condition shall be met: a 30-day running average surface RH < 80% when the 30-day running average surface temperature is between 5°C (41°F) and 40°C (104°F)~~ the mold index, calculated in accordance with Equations 6-1 through 6-7, shall not exceed a value of three (3.00)[B-22].

The building material surface under analysis shall be assigned to one of the following four sensitivity classes: Very Sensitive, Sensitive, Medium Resistant, or Resistant. ~~Materials that are naturally resistant to mold or have been chemically treated to resist mold growth may be able to resist higher surface relative humidities and/or to resist for longer periods as specified by the manufacturer.~~ The ~~criteria~~ sensitivity class used in the evaluation and the rationale for its selection shall be stated in the report. Table 6.1.1 lists recommended sensitivity classes for various types of materials[B-23].

The initial value of the mold index (M) shall be zero ($M = 0$ at time $t = 0$). The mold index shall be accumulated for each hour using the following equation:

$$M_t = M_{t-1} + \Delta M \qquad (6\text{-}1)$$

where

M_t = mold index for the current hour

M_{t-1} = mold index for the previous hour

ΔM = change in mold index, calculated for each hour using Equation 6-4 or Equation 6-7 according to the conditions specified below

The mold index shall have a minimum value of zero; if $M_{t-1} + \Delta M$ yields a negative number at any time step, then M_t shall be set equal to zero at that time step.

If the surface temperature (T_s) is greater than 0°C (32°F) at the current hour, then the critical surface relative humidity for mold initiation (RH_{crit}) (expressed as a percentage) shall be calculated using Equation 6-2 or 6-3, according to the material sensitivity class (see also Figure 6.1):

Very Sensitive Class or Sensitive Class

$$RH_{crit} = \begin{cases} -0.00267T_s^3 + 0.160T_s^2 - 3.13T_s + 100 \text{ when } T_s \le 20°C, \\ 80 \text{ when } T_s > 20°C \quad [T_s \text{ in } °C] \end{cases} \qquad (6\text{-}2a)$$

$$RH_{crit} = \begin{cases} -0.0004578T_s^3 + 0.09333T_s^2 - 6.306T_s + 221.21 \\ \text{when } T_s \le 68°F, \\ 80 \text{ when } T_s > 68°F \quad [T_s \text{ in } °F] \end{cases} \qquad (6\text{-}2b)$$

Medium Resistant Class or Resistant Class:

$$RH_{crit} = \begin{cases} -0.00267T_s^3 + 0.160T_s^2 - 3.13T_s + 100 \text{ when } T_s \le 7°C, \\ 85 \text{ when } T_s > 7°C \quad [T_s \text{ in } °C] \end{cases} \qquad (6\text{-}3a)$$

$$RH_{crit} = \begin{cases} -0.0004578T_s^3 + 0.09333T_s^2 - 6.306T_s + 221.21 \\ \text{when } T_s \le 44.6°F, \\ 85 \text{ when } T_s > 44.6°F \quad [T_s \text{ in } °F] \end{cases} \qquad (6\text{-}3b)$$

If the relative humidity at the material surface (RH_s) (expressed as a percentage) is greater than RH_{crit} at the current hour, then an increase in the mold index shall be calculated using Equation 6-4[B-24]:

$$\Delta M = \frac{k_1 k_2}{168 \times \exp\left(\begin{array}{c}-0.68 \ln T_s - 13.9 \ln \mathrm{RH}_s + \\ 0.14 W + 66.02\end{array}\right)} \quad [T_s \text{ in } °\mathrm{C}] \tag{6-4a}$$

$$\Delta M = \frac{k_1 k_2}{168 \times \exp\left\{\begin{array}{c}-0.68 \ln[(T_s - 32)/1.8] - \\ 13.9 \ln \mathrm{RH}_s + 0.14 W + 66.02\end{array}\right\}} \quad [T_s \text{ in } °\mathrm{F}] \tag{6-4b}$$

where

k_1 = mold growth intensity factor selected from Table 6.1.2 according to material sensitivity class and current value of M

k_2 = mold index attenuation factor calculated using Equation 6-5

W = parameter selected from Table 6.1.2 according to material sensitivity class

The mold index attenuation factor (k_2) shall be calculated using Equation 6-5:

$$k_2 = \max\{1 - \exp[2.3(M - M_{max})], 0\} \tag{6-5}$$

where M_{max} is the maximum mold index corresponding to the surface temperature and relative humidity at the current hour, calculated using Equation 6-6:

$$M_{max} = A + B\left(\frac{\mathrm{RH}_{crit} - \mathrm{RH}_s}{\mathrm{RH}_{crit} - 100}\right) - C\left(\frac{\mathrm{RH}_{crit} - \mathrm{RH}_s}{\mathrm{RH}_{crit} - 100}\right)^2 \tag{6-6}$$

where the coefficients A, B, and C are selected from Table 6.1.2 according to material sensitivity class.

If $T_s \le 0°C$ ($T_s \le 32°F$) or $RH_s \le RH_{crit}$ at the current hour, then a decline in the mold index shall be calculated using Equation 6-7:

$$\Delta M = \begin{cases} -0.00133 \times k_3 \text{ when } t_{decl} \le 6 \\ 0 \text{ when } 6 < t_{decl} \le 24 - \\ -0.000667 \times k_3 \text{ when } t_{decl} > 24 \end{cases} \tag{6-7}$$

where

k_3 = mold index decline coefficient specific to the material surface

t_{decl} = number of hours from the moment when conditions for mold growth changed from favorable ($T_s > 0°C$ ($T_s > 32°F$) and $RH_s > RH_{crit}$) to unfavorable ($T_s \le 0°C$ ($T_s \le 32°F$) or $RH_s \le RH_{crit}$).

The mold index decline coefficient used in the evaluation and the rationale for its selection shall be stated in the report. In the absence of specific test data for the material surface, the recommended value of k_3 shall be 0.1[B-25].

Revise Section 7.5 as follows.

7.5 Provide the moisture performance evaluation criteria used and provide results.

If conditions necessary to minimize mold growth are evaluated, provide the following:

- ~~Criteria used (80% surface RH/other)~~
- ~~Moisture content and coincident temperatures of materials~~
- Material sensitivity class and rationale for its selection
- Mold index decline coefficient and rationale for its selection
- Time series of surface temperature and surface relative humidity values
- Time series of mold index values
- Outcome (pass/fail)

If corrosion is evaluated, provide the following:

- Criterion used (80% surface rh/other)
- Time series of surface temperature and surface relative humidity values
- Outcome (pass/fail)

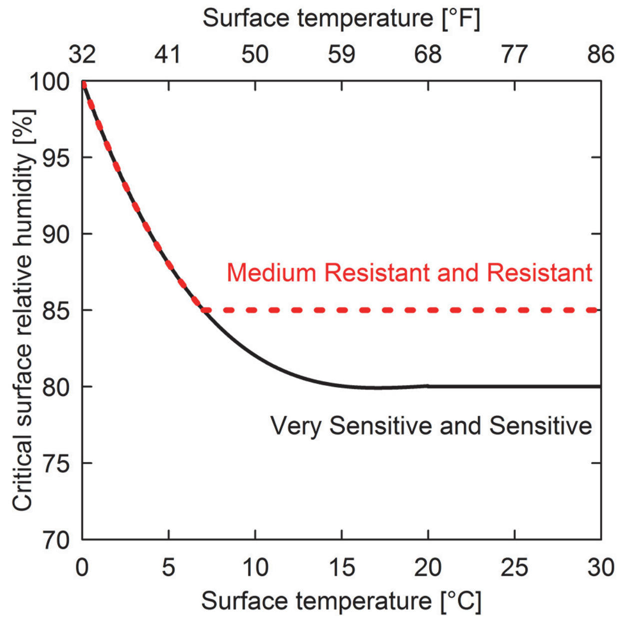

FIGURE 6.1 Critical surface relative humidity as a function of surface temperature for different material sensitivity classes.

TABLE 6.1.1 Recommended Mold Sensitivity Classes for Various Materials

Sensitivity Class	Materials
Very sensitive	Untreated wood; includes lots of nutrients for biological growth
Sensitive	Planed wood, paper-coated products, wood-based boards
Medium resistant	Cement or plastic based materials, mineral fibers
Resistant	Glass and metal products, materials with efficient protective compound treatments

TABLE 6.1.2 Parameters for Equations 6-4 and 6-6

Sensitivity Class	k_1 (if $M < 1$)	k_1 (if $M \geq 1$)	W	A	B	C
Very sensitive	1	2	0	1	7	2
Sensitive	0.578	0.386	1	0.3	6	1
Medium resistant	0.072	0.097	1	0	5	1.5
Resistant	0.033	0.014	1	0	3	1

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ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted Standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the Standards and Guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive Technical Committee structure, continue to generate up-to-date Standards and Guidelines where appropriate and adopt, recommend, and promote those new and revised Standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date Standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating Standards and Guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

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12/16